has not, previous to the current expansion of the Service, been used in large numbers of R.A.F. aeroplanes. The simplicity and clearness of its indications are obvious after a glance at the dial, in which a little aeroplane is fixed against the moving background represented by the horizon line. Any displacement in the lateral or fore and aft axes is immediately recognisable without mental translation. The lateral indication is shown also in degrees by the movement of a triangular luminised datum against a scale on the upper half of the dial.

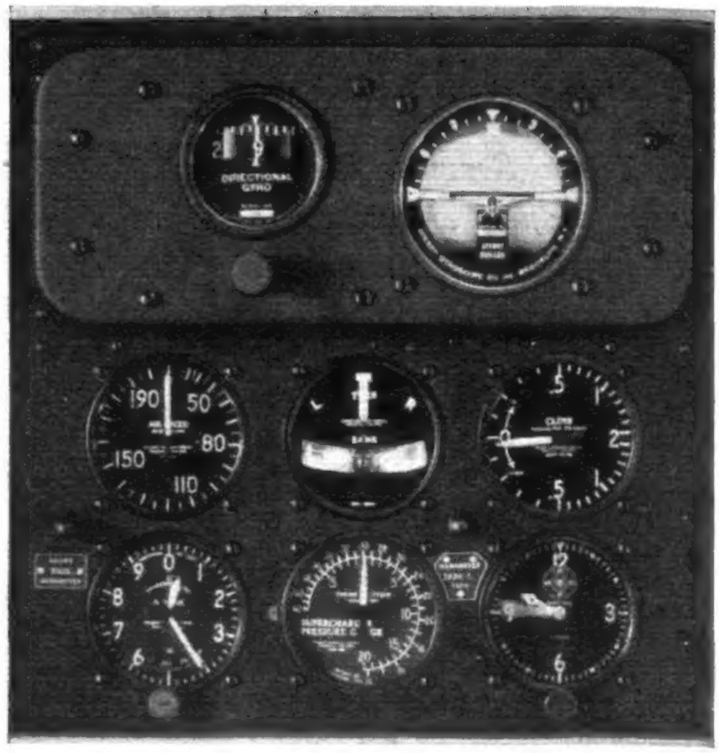
The soul of the instrument consists of a small gyro set horizontally—that is, with the spindle vertical. The wheel tends to remain truly horizontal in relation to the earth, and is maintained in that position by a set of pendulous vanes, each covering half of an opening through which the air which drives the gyro is exhausted. Tilt or deviation of the wheel from the true horizontal opens one of these apertures to a wider extent, and the reaction of the increased flow of air presses the swinging base of the gyro back into the true vertical—the base and vanes being set at right angles to the horizontal plane of the wheel. As the wheel remains horizontal irrespective of movements of the aircraft, it follows that the aeroplane, together with the case of the instrument, is revolving round the wheel which is fixed in space. That movement of the case relative to the wheel is represented on the dial by a corresponding movement of the horizon line, transferred from the gimbal of the gyro.

Free Gyro Characteristics

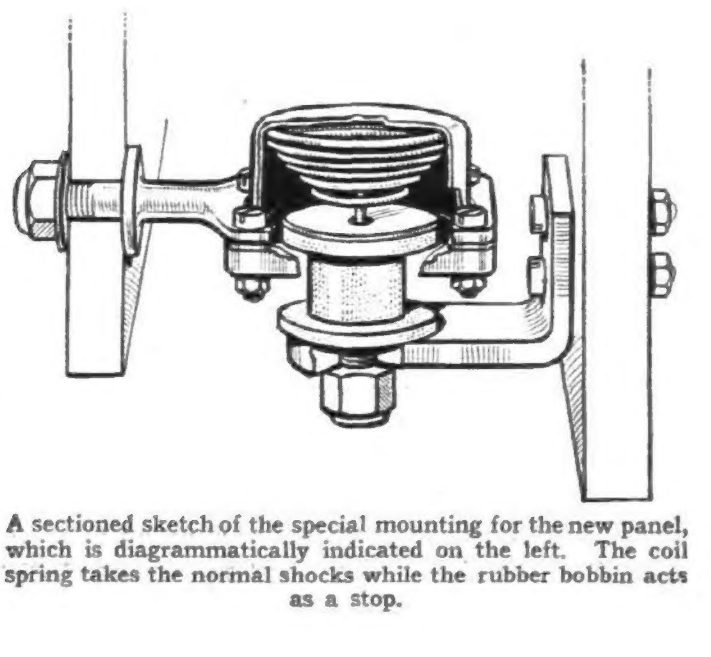
Similarly, in the Directional Gyro the wheel remains fixed in space, revolving at 12,000 revolutions per minute. This time, however, the plane of the wheel is vertical, and athwart the aeroplane when the instrument is reading zero; the spindle is horizontal in flying position, and at that reading is in the fore and aft line of the real aeroplane. As in the case of the Artificial Horizon, the case revolves round a wheel fixed in space, and gives readings in degrees against that datum.

Both these instruments, therefore, contain free gyros—the wheel in each of them is not constrained in any way. In the Directional Gyro it can revolve in its gimbals in azimuth 360 degrees, and the instrument will remain in action up to a 55-degree tilt in all attitudes. It is easily and rapidly reset if this angle is exceeded, but during acute acrobatics it would be as well temporarily to cage the gyro by pushing in the resetting knob The Horizon allows a 60-degree climb or glide and a 90-degree bank before the limit stops are reached. If these angles are exceeded the Gyro must be allowed a few minutes in which to settle.

These limitations on any free gyro make it necessary for military aircraft to carry a gyro which is restrained by a spring. Service machines, either in war or during exercises, may require to be thrown into acute attitudes, and in all these manœuvres the spring-controlled gyro of the turn indicator will continue to give an accurate indication of the direction and approximate rate of turn of the aircraft, together with an indication of the correctness or otherwise of the angle of bank for that rate of turn. To enable the pilot to make a satisfactory recovery from these extreme attitudes, a turn indicator is essential.



A typical American array of a few years ago, used on the Boeing 247s. Above is the Sperry free gyro panel, while below, from left to right, can be seen (top row) an A.S.I., a turn and bank indicator, and a rate-of-climb indicator, and (bottom row) a sensitive altimeter, a boost gauge, and a clock.



A sectioned sketch of the special mounting for the new panel, which is diagrammatically indicated on the left. The coil spring takes the normal shocks while the rubber bobbin acts as a stop.

The three gyro instruments are air driven, frequently by means of the suction from a pair of venturi tubes, or, in the most modern aircraft, by a suction pump driven from an engine, thus obviating the drag of the venturis. In either case, the suction might be too great at high speeds, and a relief valve has therefore been provided to maintain the suction at not more than 4 in. of mercury; all three instruments are connected to this relief valve.

Like the two Sperry instruments, the Smith rate-of-climb indicator is a newcomer to the dashboards of R.A.F. aeroplanes. Its use and value will be apparent from the earlier paragraphs describing flight in thick weather. It must be remembered that the rate of rise or fall of an aircraft may depend upon other factors than its angle of climb or glide, the engine revolutions, and the air speed. If any other factor is in existence the effect of its presence can be measured on the rate-of-climb indicator. Suppose, for instance, that an aeroplane flying level at fixed engine revolutions and air speed were to fly into an up-current, it would immediately begin to gain height at a rate not exactly known to the pilot unless he were to check the readings of his altimeter against a stop watch.

A Case in Point

Something like this has, on one occasion at least, resulted in the crash of a large passenger-carrying machine in Iraq. Hot air rises from a vast expanse of desert and comes down over snow-covered mountains in the north or east. A Vernon, heavily loaded with sick men being evacuated from a frontier force in action, flew into this current, which had a velocity greater than the heavily loaded machine. In the end, despite full throttle, the pilot came down in a narrow valley out of which the aeroplane could not be flown, and which was in hostile country. The personnel were rescued by Bristol Fighters and the aircraft abandoned to the advancing enemy. From that time forward the R.A.F. in that country fitted its craft with home-made rate-of-climb indicators, which were devised by the late Flt. Lt. F. M. Rope, killed in the crash of R101.

There remains only the new type of sensitive altimeter in which the pointers read like those of a clock—one indicating thousands of feet, and the other hundreds. There is no question about the extreme sensitivity of the instrument; it will measure the difference in height if held in the hands about knee level, and then raised to above the head, while to climb one flight of stairs in an ordinary house gives a clearly appreciable reading which may be reversed exactly to zero by descending the same flight. This sensitiveness is obtained by the provision of a special diaphragm which gives a very